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Anatomic and reverse shoulder arthroplasty for management of type B2 and B3 glenoids: a matched-cohort analysis

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Background: Severe glenohumeral osteoarthritis (GHOA) with posterior glenoid erosion remains challenging to address for shoulder surgeons. Whereas anatomic total shoulder arthroplasty (TSA) has historically been the treatment of choice, reverse shoulder arthroplasty (RSA) offers an alternative option. Limited evidence exists directly comparing these 2 treatments in a similar patient population. The purpose of this study was to compare the clinical outcomes of patients with GHOA and Walch type B2 and B3 glenoid morphologies treated with TSA vs. RSA.

Methods: We performed a multicenter retrospective cohort study of patients with GHOA who were treated with primary shoulder arthroplasty and had a minimum follow-up period of 2 years. Preoperative computed tomography was used to determine type B2 and B3 glenoid morphology as described by the modified Walch classification. Three-dimensional perioperative planning software was used to characterize glenoid retroversion and humeral subluxation. Patients were categorized based on type of arthroplasty (TSA or RSA) and were matched 1:1 by sex, Walch classification, and age. Patient-reported outcome measures, active range of motion, presence and severity of glenoid loosening, and complications were compared. The percentage of patients who reached previously established clinically significant thresholds of the minimal clinically important difference and substantial clinical benefit for the American Shoulder and Elbow Surgeons score was also comparatively assessed.

Results: In total, 202 patients (101 per group) with GHOA and type B2 or B3 glenoids were included in the 1:1 matched analysis. The mean length of follow-up (± standard deviation) was 39 ± 18.7 months. The cohorts were well matched, with no differences in sex, age, American Society of Anesthesiologists score, body mass index, preoperative glenoid morphology (Walch classification), glenoid retroversion, or posterior subluxation ($P > .05$). RSA was associated with a lower postoperative visual analog scale pain score (0.5 in RSA group vs. 1.2 in TSA group, $P = .036$); however, no other no other significant differences in patient-reported significant differences in patient-reported outcome measures were found. Most patients in both groups (95.0% in TSA group vs. 98.0% in RSA group, $P = .436$) reached the minimal clinically important difference, and 82% of TSA patients and 90% of RSA patients reached the substantial clinical benefit value ($P = .292$). No significant differences in the overall complication rate ($P = .781$) and active range of motion were found, with the exception of internal rotation (scored on a numeric scale) being worse in the RSA group (2.7 preoperatively and 5.2

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postoperatively in RSA group vs. 3.9 and 6.5, respectively, in TSA group; $P < .001$). Baseplate loosening occurred in 2 RSA cases, and 29 TSA cases had glenoid radiolucencies ($P < .001$), with 3 grossly loose glenoid components.
Conclusion: Primary RSA results in short-term outcomes largely comparable to those of TSA in patients with Walch type B2 or B3 glenoid morphology. Both TSA and RSA provide substantial clinical benefit to patients with significant posterior glenoid wear.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Reverse shoulder arthroplasty; anatomic total shoulder arthroplasty; outcomes; Walch; glenoid morphology; glenohumeral osteoarthritis

Glenohumeral osteoarthritis (GHOA) is a painful and debilitating degenerative condition. Long-term studies have shown reliable improvements in pain and function with anatomic total shoulder arthroplasty (TSA).[7,17,36] However, factors such as rotator cuff degeneration and glenoid deformity, namely asymmetrical glenoid wear patterns, excessive retroversion, bone loss, and posterior humeral head subluxation, are challenging to address and contribute to inconsistent outcomes of TSA.[12,16,25,42] Walch et al[41] devised a classification for assessing glenoid wear patterns. The type B2 glenoid is characterized by the creation of a biconcave glenoid due to eccentric posterior erosion and posterior humeral subluxation. The Walch classification was later updated to include type B3, which is defined as severe posterior erosion leading to a mono-concave glenoid with at least 15° of retroversion or 70% posterior humeral head subluxation.[1,3] The posterior erosion in both type B2 and type B3 glenoids leads to alterations in the joint center of rotation, joint subluxation, and tissue tension, further complicating soft-tissue balancing during TSA.[2,8,12,38]

Surgical management in patients with type B2 and B3 glenoids remains controversial. Although TSA in conjunction with eccentric reaming to correct glenoid version has historically been the treatment of choice,[13,24] correction of excessive retroversion compromises the subchondral bone and leads to excessive joint line medialization, potentially resulting in instability and glenoid component loosening.[5,26,33] Reverse shoulder arthroplasty (RSA) has recently been advocated as an alternative option for severe glenoid morphology with an intact rotator cuff.[6,9,11,14,28,37] Several studies have reported good to excellent mid-term clinical outcomes with low rates of baseplate loosening using RSA for type B2 and B3 glenoids with an intact rotator cuff.[13,22,28,40]

To date, short-term studies comparing TSA and RSA for GHOA with an intact rotator cuff have shown no differences in outcomes and value.[19,31] Little investigation has been performed directly comparing the use of RSA vs. TSA in treating severe type B2 and B3 glenoid wear patterns, with most studies having been limited in sample size. The purpose of this retrospective matched-cohort study was to compare the outcomes of patients with type B2 or B3 glenoid morphology with an intact rotator cuff treated with RSA vs. TSA. We hypothesized that TSA would be associated with higher postoperative American Shoulder and Elbow Surgeons (ASES) scores.

Methods

Patient selection

A multicenter retrospective review was performed at 2 metropolitan orthopedic specialty hospitals located in different regions of the United States (Northeast and Southeast). Data from both prospectively maintained registries (Outcomes Based Electronic Research Database [OBERD], Columbia, MO, USA; CareSense, Conshohocken, PA, USA) were combined to include all patients with GHOA and intact rotator cuffs treated with anatomic TSA or RSA between 2007 and 2019. The inclusion criteria consisted of (1) primary TSA or RSA for the treatment of GHOA with an intact rotator cuff, (2) minimum follow-up period of 2 years, (3) complete preoperative and postoperative outcome scores, (4) availability of preoperative advanced imaging to assess the glenoid wear pattern according to the modified Walch criteria,[1] and (5) confirmed type B2 or B3 glenoid morphology. Two cohorts were created based on the operation performed, and a matched-cohort analysis was used to compare the TSA and RSA groups. The TSA cohort was matched to the RSA cohort at the largest possible ratio (1:1) based on sex, Walch glenoid morphology, and age using a nearest-neighbor matching algorithm, without replacement.

Surgical technique

All procedures were performed by 1 of 2 high-volume shoulder and elbow fellowship-trained surgeons. A deltopectoral approach was used in all cases. A lesser tuberosity osteotomy was performed during TSA, whereas a subscapularis peel was used during RSA. Direct intraoperative visual assessment of the rotator cuff was performed in all cases to confirm its integrity. Patients undergoing TSA were treated with a standard cemented all-polyethylene glenoid component. No augmented anatomic glenoid components were used. All patients undergoing RSA received the same implant system (AltiVate Reverse; DJO Surgical, Austin, TX, USA). The RSA system included a glenosphere designed to have a center of rotation lateral to the glenoid (diameter range of 32-40 mm and lateralized center-of-rotation range of 2-10 mm) and a humeral stem with a 135°

neck-shaft angle. All patients received an uncemented, inlay, standard-length humeral component. No patient underwent glenoid bone grafting. All patients were treated by a similar postoperative rehabilitation protocol, which involved restricted shoulder range of motion in an immobilizer, followed by gradual and progressive range of motion through a physician-directed protocol.

Clinical outcome assessment

Demographic data including age, body mass index (BMI), and American Society of Anesthesiologists score were gathered from electronic medical records. Preoperative and most recent postoperative patient-reported outcome measures (PROMs) and active range of motion were compared. PROMs analyzed include the American Shoulder and Elbow Surgeons (ASES) score, visual analog scale pain score, and Single Assessment Numeric Evaluation rating, defined based on patient self-evaluation of the upper extremity as a percentage of normal (with 100% being normal). Improvements in ASES scores were compared by use of threshold minimal clinically important difference (MCID) (13.6) and substantial clinical benefit (SCB) (31.5) ASES scores as defined by Simovitch et al[34,35] and reported as the percentages of patients reaching the MCID and SCB value. Active range of motion was reported through goniometer-based measurements of external rotation and forward elevation. Internal rotation was measured based on the highest vertebral level of the spine reached by the thumb of the examined arm, as described previously in the literature.[39] The internal rotation scoring scale, based on the level the patient was able to reach, was as follows: buttock or greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points. In addition, complications were prospectively recorded and compared between groups.

Radiographic evaluation

Preoperative radiographs, cross-sectional advanced imaging (magnetic resonance imaging or computed tomography [CT]), clinic notes, and operative reports were reviewed to confirm the diagnosis. Two independent shoulder and elbow surgeons classified glenoid morphology according to the modified Walch criteria using CT and/or magnetic resonance imaging. Any discrepancy was resolved by consensus, with confirmation by the senior surgeons. Preoperative glenoid version and humeral head subluxation were determined by SurgiCase software (Materialise, Leuven, Belgium) based on anatomic landmarks previously described.[32] Sequential postoperative anteroposterior, scapular-Y, and axillary radiographs were reviewed for evidence of glenoid loosening based on the Lazarus classification.[21] Similarly, radiographs in RSA cases were evaluated for the presence of radiolucent lines around the glenoid baseplate and screws or gross loosening with a shift in position.

Statistical analysis

Demographic statistics were reported as means and standard deviations for continuous variables and as frequencies and percentages for categorical variables. Data in the TSA and RSA groups were compared by independent-sample t tests and χ^2 analysis when appropriate. These significance tests were 2-tailed, and $P < .05$ was considered significant. Adjustment for multiple comparisons was performed using the Benjamini-Hochberg method to control the false discovery rate. All statistical analysis was performed with R statistical software (version 4.2.2; R Foundation for Statistical Computing, Vienna, Austria).

Results

The final matched cohort included 202 patients with type B2 (70 per group) or type B3 (31 per group) glenoid wear and an intact rotator cuff treated with TSA or RSA for GHOA; the mean length of follow-up (± standard deviation) was 39 ± 18.7 months. The cohorts were well matched, with no differences in sex ($P > .999$), age ($P = .459$), American Society of Anesthesiologists score ($P = .223$), BMI ($P = .502$), and Walch glenoid morphology ($P > .999$) (Table I). There were 70 type B2 glenoids and 31 type B3 glenoids in both cohorts. Sixty-five percent of preoperative CT scans were successfully analyzed by the SurgiCase software. There were no differences in glenoid version and humeral head subluxation measurements for both B2 and B3 glenoid types between the TSA and RSA cohorts ($P > .05$). The average duration of follow-up was 47 months (range, 24-122 months) in the TSA group and 31 months (range, 24-85 months) in the RSA group ($P < .001$).

No differences in baseline PROMs were found between the TSA and RSA groups (Table II). Postoperatively, patients treated with RSA reported a significantly lower visual analog scale pain score (0.5 ± 1.0 in RSA group vs. 1.2 ± 2.5 in TSA group, $P = .036$). No difference in final Single Assessment Numeric Evaluation scores ($P = .292$) or ASES scores ($P = .082$) was found. The MCID for the ASES score was reached by 96 patients (95.0%) in the TSA group and 99 patients (98.0%) in the RSA group ($P = .436$) (Table III). The SCB value for the ASES was achieved by 83 patients (82.2%) in the TSA group and 91 patients (90.0%) in the RSA group ($P = .292$). When stratified by glenoid subtype, no significant differences in clinical outcomes were found between TSA and RSA for patients with type B2 or B3 glenoids (Table IV).

In terms of range of motion, no significant differences in active forward flexion or external rotation were found between the TSA and RSA cohorts either at baseline or postoperatively. Patients treated with RSA had worse internal rotation both preoperatively (2.7 ± 1.4 vs. 3.9 ± 2.5, $P < .001$) and postoperatively (5.2 ± 2.0 vs. 6.5 ± 2.1, $P < .001$). There were no differences in baseline-to-postoperative improvement in internal rotation, with average changes of 2.5 points in the RSA group and 2.6 points in the TSA group ($P = .789$).

Complications occurred in 4 RSA cases (4.0%): traumatic postoperative acromial fracture treated nonoperatively, transient postoperative neuropathy, transient

Table I Demographic data of patients with preoperative Walch type B2 and B3 glenoids matched 1:1 by sex, Walch classification, and age

	Anatomic TSA (n = 101)	RSA (n = 101)	*P* value
Age, yr	71 ± 6.3	72 ± 6.0	.459
Mean follow-up (range), mo	47 (24-122)	31 (24-85)	<.001*
Sex distribution, n (%)			>.999
Male	54 (53)	54 (53)	
Female	47 (47)	47 (47)	
Glenoid wear (Walch classification), n (%)			>.999
Type B2	70 (69)	70 (69)	
Type B3	31 (31)	31 (31)	
Glenoid version in patients with type B2 glenoids, °	−17.6 ± 6.2 (n = 40)	−19.0 ± 9.6 (n = 57)	.655
Subluxation in patients with type B2 glenoids, %	72 ± 11	76 ± 11	.223
Glenoid version in patients with type B glenoids, °	−19.0 ± 5.8 (n = 14)	−25.1 ± 10.9 (n = 18)	.292
Subluxation in patients with type B3 glenoids, %	67 ± 10	74 ± 15	.362
ASA comorbidity score*	2.3 ± 0.6	2.2 ± 0.4	.223
BMI	29.0 ± 5.3	29.8 ± 5.1	.502

TSA, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *ASA*, American Society of Anesthesiologists; *BMI*, body mass index.
Data are presented as mean ± standard deviation unless otherwise indicated.
* Statistically significant ($P < .05$).

cubital tunnel syndrome, and revision for glenoid component loosening due to trauma. In the TSA group, 3 complications were noted (3.0%, $P = .781$): subscapularis failure, transient postoperative neuropathy, and revision for an infected prosthesis. Glenoid component loosening was present in 2 RSA cases (2%); this occurred following trauma in 1 case but was atraumatic in the other case. In 29 patients (29%) treated with TSA, we observed radiolucent lines in ≥1 zone around the glenoid component ($P < .001$). Of these TSA patients with radiolucency, 13 (45%) had grade 1 loosening; 4 (14%), grade 2; 3 (10%), grade 3; and 6 (21%), grade 4. Grade 5 glenoid component loosening (ie, gross loosening) occurred in 3 patients in the TSA group ($P = .764$).

Discussion

Primary TSA and RSA resulted in excellent and largely comparable short-term clinical outcomes in well-matched patients with type B2 and B3 glenoids and an intact rotator cuff. Patients undergoing RSA had a lower postoperative pain score (0.5 ± 1.0 vs. 1.2 ± 2.5 in TSA group, $P = .036$) with a lower presence of glenoid radiolucency, although the clinical significance of the difference in postoperative pain is likely minimal. Both cohorts demonstrated few complications and similar postoperative forward elevation and external rotation; however, significantly better preoperative (3.9 ± 2.5 vs. 2.7 ± 1.4, $P < .001$) and postoperative (6.5 ± 2.1 vs. 5.2 ± 2.0, $P < .001$) internal rotation was found with TSA. Furthermore, there were similar rates of patients reaching the MCID and SCB value for the postoperative ASES score threshold in both groups. Ultimately, these short-term results should be viewed in light of the long-term revision risk when deciding the most appropriate treatment for patients with GHOA.

Historically, end-stage GHOA has been treated with TSA, which has demonstrated reliable and durable results in short- and long-term studies.[7,17,36] Strategies used to correct severe glenoid deformity and prepare the surface for implantation include anteriorly directed reaming, the use of bone graft in place of the posterior defect, and the use of posteriorly augmented glenoid components. In a study of 59 patients with type B2 glenoids treated with TSA with partial corrective reaming, favorable clinical outcome scores were reported but progressive implant loosening was present in 35% of cases at a mean radiographic follow-up of 2.7 years.[29] Because of the risk of perforation or anterior glenoid fracture, the authors also noted that eccentric reaming in TSA should be used thoughtfully in cases of excessive glenoid retroversion. Bone graft augmentation to correct retroversion remains technically challenging and is associated with inferior clinical and radiographic outcomes and higher rates of complications, such as glenoid component loosening, dislocation, and graft collapse.[20,42] Posteriorly augmented glenoid implants have gained recent popularity but have limited long-term clinical data. Iannotti et al[15] concluded that posteriorly augmented polyethylene components in type B2 glenoids have equivalent results to standard components in type A1 glenoids. However, with the worsening retroversion and medialized wear seen in type B3 glenoids, these augmented components show an increased frequency of central peg osteolysis. Moreover, a study by Ho et al[10] reported a 15% rate of center-peg osteolysis at a median follow-up of 2.4 years in arthritic shoulders with type B2 or B3 glenoids treated with TSA and a stepped augmentation. In general, a systematic review of TSA in posterior glenoid wear patterns across 9

Table II Comparison of outcome scores and range of motion by type of shoulder arthroplasty

	Anatomic TSA	RSA	*P* value
VAS pain score			
Preoperative	6.2 ± 2.5	6.0 ± 2.3	.655
Postoperative	1.2 ± 2.5	0.5 ± 1.0	.036*
Change	−5.0 ± 3.2	−5.5 ± 2.4	.362
SANE score			
Preoperative	33.9 ± 20.0	30.6 ± 18.3	.414
Postoperative	88.0 ± 18.1	91.6 ± 13.0	.292
Change	54.1 ± 25.6	61.0 ± 22.1	.184
ASES score			
Preoperative	33.6 ± 17.3	34.8 ± 15.6	.755
Postoperative	83.9 ± 21.4	89.8 ± 11.7	.082
Change	50.3 ± 23.6	55.0 ± 18.9	.292
Forward flexion, °			
Preoperative	96 ± 27	94 ± 22	.686
Postoperative	143 ± 18	141 ± 16	.655
Change	46 ± 27	47 ± 24	.970
External rotation, °			
Preoperative	25 ± 15	23 ± 14	.376
Postoperative	53 ± 17	52 ± 18	.970
Change	27 ± 18	30 ± 20	.576
Internal rotation†			
Preoperative	3.9 ± 2.5	2.7 ± 1.4	<.001*
Postoperative	6.5 ± 2.1	5.2 ± 2.0	<.001*
Change	2.6 ± 2.7	2.5 ± 2.1	.789

TSA, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *VAS*, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form.

Data are presented as mean ± standard deviation.

* Statistically significant ($P < .05$).

† The level of internal rotation was converted to a numeric scale as previously described: buttock or greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points.

studies reported glenoid component loosening in 42% of patients, higher than the rate of 29% found in our matched-cohort study.[24] These studies concluded that TSA in patients with type B2 and B3 glenoids continues to be problematic owing to high rates of glenoid-related complications and suggested that the semiconstrained RSA design may present a viable option.

RSA has recently gained popularity as a treatment option for type B2 and B3 glenoids in rotator cuff–intact shoulders because of its low rate of glenoid loosening and lack of dependence on rotator cuff function.[6,13,22,28,40] Theoretically, the semiconstrained design in RSA addresses the difficulties of recurrent posterior humeral head subluxation and posterior instability while the glenoid baseplate fixation decreases the risk of glenoid component loosening. A systematic review of 8 studies on RSA for GHOA with an intact cuff that totaled 195 patients with glenoid bone loss and/or retroversion found favorable clinical and functional outcomes at a mean follow-up of 53.6 months.[9] The Constant score showed a significant improvement from 26.8 points preoperatively to 70.8 points postoperatively, with a total complication rate of 4.7%. Common pitfalls in RSA include excessive joint line medialization, inadequate glenoid baseplate fixation, and glenoid baseplate malposition. An overly medialized joint line with uncorrected glenoid bone loss can alter soft-tissue tensioning and contribute to inferomedial impingement and inferior scapular notching. In a study of biconcave glenoids treated with RSA, scapular notching was noted in 37% of cases at a mean follow-up of 4.5 years.[28] Although notching can be minimized by placing the baseplate inferiorly with an inferior tilt, other techniques for dealing with posterior glenoid wear have since evolved.[9,11,22,23,28] Recently, Virk et al[40] analyzed patients with type B2, B3, or C glenoid wear who were treated by RSA with posteriorly augmented glenoid components. The study demonstrated excellent clinical and radiographic outcomes with no aseptic loosening at a mean follow-up of 40 months. As indications for RSA continue to expand, its role in managing severe glenoid wear will be better defined with longer-term studies.

Recent studies have compared the clinical effectiveness of TSA and RSA for the treatment of primary GHOA with an intact cuff. Polisetty et al[31] performed a retrospective matched-cohort study with a minimum follow-up period of 2 years and found that patient satisfaction, average cost-effectiveness ratio, and outcome improvements in units of MCIDs did not differ between those undergoing RSA and those undergoing TSA. However, the TSA group had a 24.2% rate of glenoid loosening and a 2.4% revision rate whereas no loosening or revision occurred in the RSA group. In another study, in which propensity score matching was performed by age, BMI, sex, preoperative ASES score, preoperative forward elevation, and glenoid morphology, similar short-term PROMs were observed but better postoperative active range of motion was noted in the TSA group.[19] Recently, Menendez et al[27] used a multicenter registry of 263 surgeons and followed up patients with GHOA and an intact cuff for up to 5 years postoperatively. The authors concluded that RSA yielded PROMs that were largely clinically similar to those of TSA, with small statistically significant improvements favoring TSA that were below the MCID threshold established by Simovitch et al.[34] Consistently with these previous studies, our findings showed that RSA provides comparable short-term PROMs with fewer cases of radiographic loosening specifically in patients with type B2 or B3 glenoids.

Coupled with studies demonstrating similar clinical outcomes between TSA and RSA for the treatment of GHOA with an intact rotator cuff, the increased utilization of RSA may be a result of concerns about anatomic glenoid component loosening and rotator cuff dysfunction after TSA.[12,19,24,25,31,33,36] Although this study found no significant differences in complications at short-term follow-up, large registry studies have demonstrated decreased revision rates in RSA. Collin et al[6] reported excellent mid-term

Table III Comparison of radiographic outcomes and number of patients who reached clinically significant thresholds for improvement in ASES score

	Anatomic TSA (n = 101)	RSA (n = 101)	*P* value
Achievement of MCID for ASES score,* n (%)	96 (95)	99 (98)	.436
Achievement of SCB for ASES score,* n (%)	83 (82)	91 (90)	.292
Presence of radiolucency, n	29	2	<.001†
Severity of radiolucency (Lazarus classification), n (%)			
Grade 1	13 (45)	—	
Grade 2	4 (14)	—	
Grade 3	3 (10)	—	
Grade 4	6 (21)	—	
Grade 5 (gross loosening)	3 (10)	2 (100)	.764
Complications, n	3	4	.781

ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *TSA*, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *MCID*, minimal clinically important difference; *SCB*, substantial clinical benefit.

* Improvements in postoperative scores were compared with threshold MCID (13.6) and SCB (31.5) ASES scores as described by Simovitch et al[34,35] and are reported as percentages of patients reaching the MCID and SCB value.

† Statistically significant ($P < .05$).

Table IV Postoperative comparison of TSA and RSA outcomes stratified by glenoid subtype

	Walch type B2 glenoids			Walch type B3 glenoids		
	TSA (n = 70)	RSA (n = 70)	*P* value	TSA (n = 31)	RSA (n = 31)	*P* value
VAS pain score	1.3 ± 2.6	0.5 ± 1.0	.082	1.3 ± 2.8	0.4 ± 1.1	.223
SANE score	87.7 ± 17.8	91.6 ± 13.9	.343	88.8 ± 19.1	91.5 ± 10.8	.658
ASES score	83.6 ± 21.5	89.6 ± 12.2	.184	84.4 ± 21.5	90.3 ± 10.7	.362
Forward flexion, °	143 ± 18	142 ± 15	.781	140 ± 17	138 ± 19	.655
External rotation, °	54 ± 19	52 ± 18	.673	55 ± 14	49 ± 17	.362
Internal rotation*	6.6 ± 2.1	5.3 ± 2.0	.004†	6.2 ± 2.1	5.0 ± 1.8	.082
Achievement of MCID for ASES score,‡ n (%)	67 (96)	68 (97)	.764	29 (94)	31 (100)	.682
Achievement of SCB for ASES score,‡ n (%)	57 (81)	63 (90)	.343	25 (81)	27 (87)	.658
Presence of radiolucency, n (%)	22 (31)	1 (1.5)	.009†	7 (23)	1 (1.5)	.107

TSA, total shoulder arthroplasty; *RSA*, reverse shoulder arthroplasty; *VAS*, visual analog scale; *SANE*, Single Assessment Numeric Evaluation; *ASES*, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form; *MCID*, minimal clinically important difference; *SCB*, substantial clinical benefit.

Data are presented as mean ± standard deviation unless otherwise indicated.

† Statistically significant ($P < .05$).

* The level of internal rotation was converted to a numeric scale as previously described: buttock or greater trochanter, 2 points; sacrum to L4, 4 points; L3 to L1, 6 points; T12 to T8, 8 points; and T7 to T1, 10 points.

‡ Improvements in postoperative scores were compared with threshold MCID (13.6) and SCB (31.5) ASES scores as described by Simovitch et al[34,35] and are reported as percentages of patients reaching the MCID and SCB value.

clinical outcomes, no evidence of component loosening, and a 94% survival rate at a minimum of 5 years' follow-up after RSA for GHOA in patients with type B1, B2, B3, or C glenoids. A meta-analysis showed a higher complication rate of 9% in patients treated with TSA compared with 6% after RSA but showed similar revision rates of 2% in the TSA group and 1% in the RSA group.[33] Consistently with this study, Parada et al[30] used an international database of primary shoulder arthroplasty procedures performed by 40 different surgeons and found short-term complication rates of 10.7% and 8.9% and revision rates of 5.6% and 2.5% after TSA and RSA, respectively.

No differences in postoperative forward elevation and external rotation were found between the TSA and RSA groups in our study. However, TSA patients demonstrated greater preoperative and postoperative internal rotation. Previous studies have shown similar results, as the medialized implant design in RSA often results in inferior internal rotation and external rotation compared with the TSA design.[19,31,37,43] A retrospective study by Triplet et al[39] concluded that primary TSA provides greater functional internal rotation than RSA. The recovery of internal rotation after RSA is likely not related to subscapularis function as Clark et al[4] reported no difference in internal

rotation motion with and without subscapularis repair. It is more likely that an impingement-free arc of motion defines the ability of RSA to restore internal rotation function. Of note, a computer simulation study of 10 type B2, B3, or C shoulders found that optimal range of motion after RSA is achieved with a glenoid implant having 10 mm of baseplate lateralization with neutral version to 5° of retroversion and a 135° angle of inclination on the humeral implant.[18] The differences in range of motion, while statistically significant, have questionable clinical significance as studies have demonstrated that even modest improvements in motion can result in clinically meaningful differences.[34] Thus, it is important to consider other clinically meaningful outcomes and potential risks when considering either TSA or RSA for patients with GHOA, including the need for revision surgery.

Our study presents a large sample size of matched patients with significant posterior glenoid wear undergoing TSA or RSA for GHOA with an intact rotator cuff. This is the only study to our knowledge with a substantial sample size of well-matched patients with posterior glenoid wear.[33] We believe this study presents a balanced analysis of the short-term outcome differences between TSA and RSA in this patient population. To minimize the risk of bias, we used propensity score matching of age, sex, and Walch glenoid classification. Furthermore, the use of preoperative planning software allows accurate and reliable assessment of preoperative glenoid retroversion and humeral head subluxation, ensuring a similar comparison of preoperative glenoid deformity in patients with type B2 and B3 glenoids. However, this study is not without limitations. The data reflect the experience of 2 high-volume surgeons and therefore may not be generalizable. Furthermore, there is inherent selection bias in this retrospective analysis as there were a variety of justifications for selecting RSA for these patients, which include anatomic characteristics, patients' preferences, support from peer-reviewed studies, and perception of risk. Having similar preoperative pathology in each cohort mitigates the impact of this limitation. With 2-year minimum follow-up, it is unknown how the long-term outcomes differ between the implant designs used. Moreover, with a shorter mean follow-up in the RSA group, higher rates of glenoid loosening and other complications could develop over time and result in deterioration of outcomes. Long-term data are needed to better assess the durability of RSA compared with TSA when treating GHOA in patients with posterior glenoid wear.

Conclusion

Primary RSA and TSA result in largely comparable short-term outcomes in patients with GHOA and an intact rotator cuff with Walch type B2 or B3 glenoid morphology. Both TSA and RSA provide substantial clinical benefit to patients with significant posterior glenoid wear. Longer follow-up is ultimately needed to determine whether the clinical outcomes and the risk of revision arthroplasty differ substantially in patients with Walch type B2 or B3 morphology undergoing RSA vs. TSA.

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